Department of Defense

The Need for Ranges and Training Areas

MARCH 1999

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EXECUTIVE SUMMARY

PURPOSE AND SCOPE

The purpose of this report is to identify and describe, in general terms, the Department of Defense's requirements for ranges and training areas to support the National Military Strategy. The scope of this report is limited to the need for ranges and training areas operated by components of the U.S. military out to 12 nautical miles from the coastline of the United States and its territories.

EVOLUTION OF MILITARY NEEDS FOR RANGES AND TRAINING AREAS

The need for land specifically reserved for training military personnel and testing weapon systems has been an accepted fact since the founding of the United States. Since that time, the number and size of military ranges and training areas have changed in response to such factors as military conflicts and changes in doctrine, weapon systems technology, and force structure. The Department of Defense must balance these factors in determining the appropriate number, location, and capabilities of its ranges and training areas.

The Department also considers economic and other policy goals and objectives in the course of determining an optimum set of ranges and training areas. The baseline for this determination is the composite of existing ranges and training areas that evolved over the course of U.S. history—expanding during wartime and periods of rapid technological advances and downsizing in post-war periods. The Department's goal has always been to maintain the capability necessary to satisfy test and training requirements while optimizing the use of land, air, and sea space.

CURRENT AND FUTURE REQUIREMENTS

The two main functions of the Department of Defense's ranges and training areas are testing weapon systems and training military forces. The Department needs a combination of highly complex and capable facilities and ranges to support testing of weapon systems under development as well as in

production. These facilities and ranges are used to collect data needed to assess how well a weapon system performs and its effectiveness, suitability and survivability. The Department also requires a variety of ranges and training areas to support all levels of warfighter training in multiple skill areas. The following general types of ranges and training areas represent the minimum requirements:

- *Air Ranges for air-to-air, air-to-ground, drop zone, and electronic combat testing and training;*
- *Live-Fire Ranges for artillery, armor, small arms, and munitions testing and training;*
- *Missile Ranges to test various missile systems and to provide access to space for military exploitation and commercial ventures;*
- *Ground Maneuver Ranges to conduct realistic, force-on-force and live-fire testing and training at various unit echelons; and*
- *Sea Ranges to conduct ship maneuvers for both training and testing.*

A long-term view of Department of Defense requirements is necessary to ensure that ranges and training areas needed for testing future technologies and weapon systems, as well as for training troops in new warfighting doctrine, will be available in the years to come. Estimating needs for ranges and training areas is essential to maintaining future military readiness. Each Military Service is responsible for determining its specific resource needs for testing newly developed systems and for training personnel both in the use of new systems, warfighting doctrine, and basic proficiency training. Although the process for determining future needs is specific to each Military Service and keyed to its unique mission requirements, the general approach is functionally similar.

A “bottom-up” process generally drives test resource needs, including those for ranges. Research and development agencies project their future needs for test resources, the period in which the resources will be required, and the extent to which they will be required for the specific systems being developed. These projections of requirements allow Military Service planners to properly plan for test and training and best allocate limited resources.

Training resource needs, including those for ranges and training areas, are driven more from a “top-down” perspective in which military planners project the amount of training required to achieve mission readiness. This entails

maintaining basic skills as well as attaining proficiency with new systems and the latest operational concepts. Since training is keyed to mission requirements, which are established by national military strategies and goals, a “strategies-to-task” relationship is used to formulate training plans. Once the top-down guidance of military planners has been promulgated, commanders must accomplish a bottom-up process to ensure that the requisite training can be supported at the locally available ranges and training areas, or to take action to acquire other assets when there is a shortfall.

Many factors are driving changes in future requirements for ranges and training areas. Some of these factors, such as Department of Defense downsizing, have led to the closure of military bases and the relinquishment of ranges and training areas at those bases. Other factors, such as advances in weapon system capability and changes in warfighting doctrine, have led to requirements for expanding existing ranges and training areas. For example, modern air-to-air warfighting tactics require three times the training area that was required 20 years ago and requirements are emerging for better urban facilities for urban warfare training. The Department of Defense recognizes that many activities compete for the use of finite land, sea, and air space resources. For that reason, the Department is taking steps to encourage more joint-service and multifunctional use of ranges and training areas, in addition to taking advantage of technological advancements and opportunities to use alternatives such as over-water ranges.

I. INTRODUCTION

Superbly trained troops and advanced, highly capable weapon systems are the foundations upon which the Department of Defense (DoD) builds, maintains, and ultimately achieves readiness. Military ranges and training areas are central to these efforts and must be planned, developed, maintained, and improved to provide realistic environments for training and testing. These ranges and training areas give U.S. troops the opportunity to train as they fight and to thoroughly test weapon systems to ensure that they function as designed and are operationally effective, suitable, and survivable for their intended use.

The foundation for current U.S. ranges and training areas was established in the early part of the 1900s. Since then, these ranges and training areas have evolved in response to military requirements and, most recently, to rapid technological and political changes. Over the next 5 years, a number of efforts will be undertaken to review the military ranges and training areas needed to support the defense strategy for the future. These efforts include internal Military Service reviews, DoD-wide reviews, two additional rounds of base realignment and closure requested by the Secretary of Defense, and an upcoming congressional review to renew the military's use of 7.2 million acres of public lands withdrawn under Public Law 99-606. To prepare for these reviews, DoD must document the factors that influence current and future needs for ranges and training areas.

BACKGROUND

Our past is the foundation for our future. A look at military ranges and training areas from the early years of the nation's history to the post-Cold War era reveals that the number and sizes of ranges and training areas have changed in response to force size, weapon systems, advances in technology, and military doctrine.

During the early settlement of the western United States and throughout the mid-1800s, the military established many military posts, forts, and temporary camps for the purpose of protecting overland mail routes and settlers. Over time,

the need for these posts, forts, and camps diminished, and many were closed. Few new facilities were established until World War II.

World War II marked the beginning of an extensive military expansion throughout the United States. This expansion was concentrated in the West as a result of fear over the potential Japanese invasion of the West Coast. In Nevada alone, the military established Army Air Corps bases at Tonopah, Stead, Minden, Lovelock, Wendover, and Winnemucca. In addition, President Roosevelt established the Las Vegas Bombing and Gunnery Range in Nevada in 1940. Now called the Nevada Test and Training Range, it is the largest military range in the western world. World War II also led to the creation of Nevada's second largest military base, the Fallon Naval Air Station.

Range requirements have evolved dramatically since that time. The Cold War brought changing requirements for ranges and training areas based on advances in weapon system technology and the need to be prepared to engage the enemy in areas around the world. The warfighting doctrine of the time with its focus on defeating a single dominant adversary required missile ranges, nuclear testing areas, and large-scale maneuver areas for mechanized units.

The end of the Cold War and the break up of the Warsaw Pact again put the U.S. military in an arena of changing requirements. The new imperative is to be able to fight and win two nearly simultaneous major theater wars separated by a great distance. U.S. forces must be capable of employing the full spectrum of military operations including operations other than war. The resulting operational environment calls for highly mobile military forces fully trained to fight at any time on the ground, in the air, and at sea.

Table 1 outlines changes in warfighting doctrine and advances in technology that have influenced the evolution of ranges and training areas just described. It gives examples of major technological innovations connected with each era of military history, highlights the changes in military doctrine, and describes the impact on the need for ranges and training areas.

Table 1. Evolution of Requirements for Ranges and Training Areas

Era	Advances in Technology	Charges in Warfare Doctrine	Impact on Need for Ranges and Training Areas
Revolutionary—Civil War	Improved firearms Improved roads and transportation	Massed battles Force on force	Minimal
Civil War—Indian War	Railroads Telegraph Repeating rifle Gatling gun	Extended logistics Better command and control	Frontier forts and military staging areas established
Pre-World War I	Airplane Artillery Machine gun Wireless radio	Combined Arms Battles Better intelligence gathering Improved command and communications	Need for airfields Need for larger firing ranges
World War I—World War II	Advanced piston aircraft Motorized combat vehicles Radio/telephones Long-range artillery Radar Atomic bomb Amphibious craft	Combined arms / massed maneuver Sustained logistics Air warfare / air control Amphibious warfare	Large ground maneuver areas Air combat areas Air-to-ground bombing areas Atomic test sites Littoral area training
Wold War II—Vietnam War	Jet aircraft Air-to-ground, air-to-air, and ground-to-air missiles Ballistic missiles Nuclear weapons Early computers Long-distance communications Improved radar Electronic combat Helicopters	Standoff targeting Short-range missile warfare Long-range missile warfare Command and control Increased detection capabilities Enemy detection capabilities degradation	Increased sizes of surface and air ranges Ballistics missiles test areas Large force training areas Large, isolated, electronically quite areas Missile test sites
Vietnam—End of Cold War	Modern jet aircraft Third-generation computers Very reliable communications Improved sensors Improved helicopters	Improved command and control Vertical envelopment by helicopter	Instrumented aircraft test and training ranges Littoral areas suitable for amphibious operations/ vertical envelopment operations
End of Cold War—Present	Improved battlefield command processes Integrated data fusion and information distribution for tactical awareness Extended-range intercept weapons	Warfighting experiments Shift from single, major threat to diverse threats from many sources Maximum integration of forces Non-lethal training Urban warfare	Integration/networking of test ranges Training and test integration Highly instrumented training and test ranges Non-lethal training areas Extended ranges for missile intercept

PURPOSE AND SCOPE

The purpose of this report is to identify and describe the DoD's requirements for ranges and training areas to support the National Military Strategy. This report is limited to the need for ranges and training areas operated by components of the U.S. military within 12 nautical miles of the United States and its territories.

CONTENT

This report addresses the imperatives behind the military's need for ranges and training areas (Chapter 2), the factors that influence a continuing evolution in those needs (Chapter 3), and the current and future requirements for ranges and training areas (Chapter 4).

Appendix A lists major ranges and training areas within the scope of this report by location and Military Service and identifies their major uses. Appendix B is a bibliography of pertinent references that supply amplifying information.

II. MILITARY STRATEGY IMPERATIVES

The need for ranges and training areas evolves from hierarchical guidance from the President, the Congress, the Chairman of the Joint Chiefs of Staff, and the highest echelons of the Military Services. This guidance is embodied in the National Security Strategy, the National Military Strategy, and other departmental strategy and vision documents. This chapter provides a synopsis of that hierarchical guidance. For additional information, refer to Appendix B, which provides bibliographical information on referenced documents.

NATIONAL SECURITY STRATEGY

The United States is pursuing a forward-looking national security strategy with three core objectives: (1) to enhance security; (2) to bolster economic prosperity; and (3) to promote democracy abroad. A network of institutions and arrangements with distinct missions but a common purpose—to secure and strengthen the gains of democracy and free markets while turning back their enemies—are laying a foundation for security and prosperity in the 21st century. The United States must have the tools necessary to carry out this strategy. One of these tools is a military force capable of deterring aggression and responding to the full spectrum of threats and crises that may arise.

NATIONAL MILITARY STRATEGY

The role of the Military Services is further defined by the National Military Strategy, which states that U.S. Armed Forces must be able to fight and win two nearly simultaneous major theater wars separated by a great distance. In addition, U.S. military forces must prepare for a wide range of contingency operations in support of U.S. interests, such as smaller scale contingencies, peacekeeping, and non-combatant evacuation operations. Finally, U.S. forces must be able to conduct a broad range of military missions while retaining adequate reserve capabilities.

STRATEGIC CONCEPTS

The four strategic concepts of our National Military Strategy, listed below, guide the Military Services in carrying out their respective roles and missions. These concepts set the strategic direction of the Armed Forces for the next 3 to 5 years:

- *Strategic Agility—the timely concentration, use, and support of U.S. military power anywhere, when the United States wants it, and at a speed and tempo that the enemy cannot match.*
- *Overseas Presence—the visible presence of U.S. forces and supporting elements, strategically positioned forward in and near key regions.*
- *Power Projection—the ability to rapidly and effectively deploy U.S. military forces from multiple, separated locations and to support those forces until the conflict is resolved.*
- *Decisive Force—making sure sufficient military power is committed to overwhelm an enemy, establish new military conditions, and achieve a political resolution favorable to U.S. interests.*

How our military leaders view their missions and the capabilities and doctrines necessary to achieve those missions are articulated in a series of "vision" statements.

VISIONS OF OUR MILITARY LEADERS

The Chairman of the Joint Chiefs of Staff and each of the Military Services have published vision statements on the role of the Military Services as specified by Congress. These statements provide insight not only into how the Joint Staff and each Military Service views its role, but also into how each performs its assigned functions, develops the requisite capabilities and doctrine, and prepares forces to satisfy national goals and objectives.

Joint Vision 2010

"Joint Vision 2010" is an operational warfighting vision promulgated by the Chairman of the Joint Chiefs of Staff. As such, it articulates the concepts that the Chairman views as key to achieving future U.S. national security and national military objectives. It also provides guidance to the Military Services for their use

in planning how to accomplish their missions. Recognizing the importance of highly trained forces equipped with state-of-the-art weaponry, “Joint Vision 2010” provides four new operational concepts:

- *Dominant Maneuver—a full picture of the battlefield, advanced mobility platforms, and agile organizations.*
- *Precision Engagement—ability to deliver the desired effects on any target at the right time and place.*
- *Full-Dimensional Protection—multiple layers of protection for U.S. forces and facilities at all levels.*
- *Focused Logistics—bringing together information, logistics, and transportation technologies.*

Collectively, these concepts are intended to provide what is termed “full spectrum dominance”— the ability to fight and decisively win across the full spectrum of conflict, no matter what the battlefield conditions or nature of conflict. Achieving this capability will require both:

- *Information Superiority—integration of superior information communication technology, and interoperability of disparate systems to act faster than the adversary in every dimension, and*
- *Technological Innovation—leading to the development of new doctrine, organizations, training and education, materiel, leadership, and personnel.*

The vision statements of the Military Services discussed below elaborate on the specific operational drivers and enabling technologies necessary to support the military strategy.

U.S. Army—“Army Vision 2010”

The Army has developed an operational vision that supports both the National Military Strategy and Joint Vision 2010 to achieve full-spectrum dominance. According to the Army’s vision, the United States will field

> …the world’s best Army, a full spectrum force trained and ready for victory, equipped with the most modern weapons and equipment the country can provide, that is able to respond to our Nation’s needs, and is changing to meet the challenges of today, tomorrow and the 21st century.

The Army is striving to turn this vision into reality through a process called Force XXI, which will provide for complete digitization of the battlefield for tomorrow's Land Warrior. Army Vision 2010 identifies the operational imperatives and enabling technologies the Army needs to achieve real situational understanding and full-spectrum dominance both on the battlefield and in cyberspace. If the Army is to achieve information superiority and combat overmatch, as well as to maintain its dominant maneuver and precision strike capability, it must not only conduct ongoing, essential research and development, but also invest in leap-ahead science and technology.

To achieve the goals of Force XXI and Army Vision 2010, the Army must continually test new enabling technologies and recapitalize its current weapon systems with product improvements, which will require further testing. With that in mind, the Army needs assurance that the Nation's test resource base, including its land and facilities, is available and keeping pace with the advanced warfighting systems it must evaluate.

Army training for Force XXI must train leaders, soldiers, and units to achieve capabilities contained in Force XXI doctrine. The Army must train to be proficient at executing the following six "patterns of operation":

- *Project the force,*
- *Protect the force,*
- *Shape the battlespace,*
- *Conduct decisive operations,*
- *Sustain the force, and*
- *Gain information dominance.*

The Army's Force XXI training strategy envisions a training "revolution" that will support these patterns of operation by balancing training between three "domains":

- *Live training by units with actual weapons systems on ranges and land,*
- *Virtual training on simulation systems that replicate actual weapons systems, and*

- *Constructive training supported by simulations that replicate units and weapon systems.*

Live training will be the foundation of the Army's training strategy. The unprecedented capabilities of Force XXI units and weapon systems will require larger and more capable firing ranges as well as expanded maneuver space in training areas. Army range development will support these requirements as the centerpiece of future training.

U.S. Navy—"Forward … From the Sea"

"Forward …From the Sea," the Navy's vision document, states that the purpose of U.S. naval forces is to project the power and influence of the United States across the seas to foreign waters and shores in both peace and war. The Navy's main asset is its unique ability to rapidly deploy ready-to-fight, fully supported naval expeditionary forces in peacetime operations, in response to crises, and in regional conflicts. U.S. naval forces are the foundation of peacetime forward-presence operations and overseas response to crises. Naval forces currently engaged in forward areas have the objectives of preventing conflicts and controlling crises.

As a direct result of the changing world power structure, there has been a fundamental shift in naval operational focus. The shift is from defending against a global maritime threat and maintaining control of the sea lines of communication and toward projecting power and influence across the sea in response to regional challenges. From this shift in operational focus come training and testing requirements that must be met through use of suitable ranges.

U.S. Air Force—"Global Engagement: A Vision for the 21st Century Air Force"

"Global Engagement: A Vision for the 21st Century Air Force" flows from the National Security Strategy and is a continuing commitment to provide the United States with the air and space capabilities required to deter, fight, and win. This vision is grounded in the concepts of Joint Vision 2010. Moreover, it embodies a belief that in the 21st century, the strategic instrument of choice will be air and space power.

This strategic vision for the Air Force is based on a new understanding of what air and space power mean to the nation—the ability to hit an adversary's strategic centers of gravity directly as well as prevail at the operational and tactical levels of warfare. Global situational awareness, the ability to orchestrate military operations throughout a theater of operations, and the ability to bring intense firepower to bear over global distances within hours to days gives national leaders unprecedented leverage.

"Global Engagement: A Vision for the 21st Century Air Force" addresses the entire Air Force—people, capabilities, and infrastructure—and charts the course of the Air Force into the first quarter of the next century. Although this strategic vision document establishes overall direction, the Air Force will develop a formal long-range plan, which details the steps to implementing the vision.

U.S. Marine Corps—"Forward…From the Sea," and The Commandant's Planning Guidance.

As outlined in the Commandant's Planning Guidance, the mission of the Marine Corps is to make Marines and to win the nation's battles. "Forward…From the Sea" emphasizes that the amphibious capability of the Marine Corps, its seaborne capability, and its expeditionary nature make it uniquely suited for military operations "in any clime or place." Indeed, in the nineties the Marine Corps conducted operations in the deserts of Southwest Asia, the mountains of Bosnia, and the littorals of Somalia and Liberia. To meet warfighting requirements of the next century, the Marine Corps must maintain—and in some cases, expand—its capability to train in any environment and terrain.

A New Generation of Enhanced Systems

Achieving U.S. strategic goals as we move into the 21st century will require new generations of military systems as well as more diverse and complex training regimes for the warfighters. The continuing acceleration of new technology development in microelectronics, computers, communications, sensors, and aerospace materials has triggered the development of systems of far greater complexity and sophistication than those currently in use. In turn, these systems spawn requirements for more advanced test capabilities, as well

as instrumented ranges and training areas where realistic, live-fire, force-on-force joint training exercises can be conducted.

Itemized below is a sampling of some of the new and enhanced capabilities being implemented by the Military Services in support of their role in Joint Vision 2010 warfare.

- *Weapon Systems*
  - *Aircraft*—a mix of new air-superiority and attack aircraft with improved maneuverability and flight envelopes, precision strike platforms, vertical and short take-off and landing aircraft, tilt-rotar aircraft, transport aircraft, and long-endurance unmanned aerial vehicles.
  - *Missiles*—vastly improved long-range missiles with smart submunitions requiring longer ranges and greater impact and safety footprints. Operations in more diverse terrain and conditions using new techniques for sensors and fuzing will become more common.
  - *Munitions*—deep penetration against hard and buried targets and tunnels with capabilities for reduction of effects from weapons of mass destruction.
  - *Reconnaissance, Surveillance, and Target Acquisition*—surveillance and targeting systems that can coordinate the use of a wide range of weapons.
  - *Armor*—lighter and more versatile vehicles and sensor systems to achieve a dominant maneuver capability, including more integrated logistics support.
  - *Artillery*—ground artillery with longer ranges and shorter set-up times and lighter weight artillery to enhance ship-to-shore mobility and improved munitions.
  - *Ballistic Missile Defense*—longer range missiles, from land-based and shipboard platforms, conducting endoatmospheric to low exoatmospheric intercepts against increasing capable, sophisticated, and wide spread threat ballistic missiles.
  - *Urban Warfare Equipment*—precision wall, ceiling, and floor breaching devices; inter-building transport systems; precision weapons requiring no back-blast impact areas; building and room surveillance systems; intra-squad personal communications devices; non-lethal weapons; and close-quarter battle protective armor.

- *Command, Control, and Communications*
  - *Information Systems*—improved information collection, processing, and transmission capabilities integrated with new operational concepts.
  - *Battlefield Systems*—battlefield combat identification systems and enhanced situational awareness through battlefield digitization.
- *Space Systems*
  - Surveillance Systems—space-based surveillance systems for theater and national missile defense systems.
  - Satellite Systems—new navigation and communication satellite systems.
  - *Launch Systems*—new generation of rocket boosters.
- *"System of Systems"*
  - *National Missile Defense Systems*—may include surveillance systems; interceptor systems; and command, control and communication systems.
  - *Integrated Air-Defense Systems*—may include ground-based surveillance radar, missile launch batteries, missile tracking and control sites, airborne surveillance and tracking radar, fighter aircraft, and anti-aircraft artillery systems.

The DoD's need for ranges and training areas must be assessed within the context of evolving weapon system capabilities and warfighting requirements. Developing these new capabilities and requirements necessitates both sophisticated test processes to verify and validate new systems and complex training regimes to ensure that the warfighter is fully capable in their use.

III. FACTORS INFLUENCING REQUIREMENTS

The DoD uses ranges and training areas for two main functions—testing weapon systems and training military forces. In the future, DoD will also use ranges and training areas to support Joint Experimentation. The requirements for ranges and training areas to support these functions are driven by such factors as the performance capabilities, safety, security, and employment environments of weapons being tested; the force structure, basing mode, and warfighting doctrine of the Service members being trained; and the size and elements of the force, weapon systems, and warfighting doctrine employed in the Joint Experimentation program.

TESTING

Ranges are needed to support the test and evaluation of new equipment and weapon systems under development, improvement of existing systems, and stockpile reliability testing. The fundamental purpose of testing is to collect data necessary for decision makers to assess system technical performance, operational effectiveness, suitability, and survivability. Testing is an integral part of the equipment and weapon system development process. Development testing verifies that the item performs in accordance with the design specifications. Complementary to developmental testing, operational testing is required to determine the effectiveness, suitability, and survivability of new and modified equipment. Such testing validates that a weapon system, operated by a user, fills the operational shortfall for which it was originally requested. The type of range required for advanced developmental testing and for most operational testing depends upon the characteristics of the weapon system in test. Long-range weapons, missiles, and aircraft, for example, need expansive ranges that provide necessary safety buffer zones. Electronic combat and communication systems need large ranges within which electromagnetic emissions may be carefully controlled. Equipment that does not involve weaponry, such as trucks, also requires appropriate areas in order to accomplish the tests necessary to validate its primary and ancillary missions.

The types of systems under development drive test range requirements. The following influence test range size and locations:

- *Risk—research, development, test and evaluation is inherently risky because you cannot be sure of how a system will behave.*
- *Launch characteristics of system being tested—acceleration, velocity, altitude, and attitude.*
- *Performance envelope of system being tested—range, velocity, warhead, and electromagnetic environmental effects.*
- *Operational scenario being evaluated—short-, medium-, and long-range anti-aircraft and anti-submarine warfare, terrain conformance, electronic combat, captive/shape/live, mission profile, and optimum launch altitude.*
- *Safety footprint—live ordnance, overflight characteristics, electromagnetic environmental effect emissions, hazardous materials, and toxicity.*
- *External issues—population safety, marine mammals, historical site preservation, endangered species, noise, and access.*
- *Security—secure facilities and buffer zones to ensure that classified systems and modes of operation are not compromised.*
- *Environment—capability to test systems in all types of environmental conditions, such as extreme cold, desert, tropics, and temperate; and special features needed for test capabilities such as seismic stability, long flat terrain, and look-down capability.*

Performance

The DoD is currently developing a number of new, advanced-technology weapon systems that constantly challenge the limits of U.S. ranges in terms of safety, security, and size. Advances in technology are allowing weapons to go farther and faster with more explosive warheads than in the past. These weapons require an adequate amount of land to ensure that any nearby civilian populations are neither harmed nor disturbed by testing early in the morning or late at night. The following are examples of the kinds of weapon systems the Department plans to test and/or field within the next 10 years:

Joint Service

- *Joint Strike Fighter employs the newest in fighter aircraft technology with variants to meet Navy, Air Force and Marine Corps requirements. This multirole supersonic aircraft will have a combat radius up to 30 percent farther, accelerate 30 percent faster, and have 35 percent better agility.*

- *National Missile Defense requires a vast, open, over-water range to accommodate safety and the performance envelope of the threat targets and the Ground Based Interceptor. The range the Ground Based Interceptor is launched from must be a treaty compliant site for National Missile Defense testing.*

Army

- *105-mm Terminally Guided Projectile Advanced Technology Demonstration, with a 40-km range.*
- *Guided Multiple Launch Rocket System, with a range from 45 to 100 km.*
- *155mm Extended Range Artillery Projectile, designed to support the Crusader program with a range out to 60 km.*
- *155-mm High-Capacity Artillery Projectile, which will have a range of 30 to 50 km.*
- *Army Tactical Missile System (ATACM) Block II/Brilliant Anti-Armor Tactical (BAT) pre-planned product improvement program, which requires extensive use of land, since the BAT submunitions are capable of gliding over 80 km from their dispense point in search of a ground target.*
- *Future Combat System, Future Infantry Vehicle and Future Scout and Cavalry System will employ advanced mobility technology through use of adaptive suspension and banded tracks, thus enabling the vehicles to traverse terrain faster (up to 25%), improve handling, turning radius, and ride characteristics, and will require land with diverse topography and climates to stress both on-road and off-road capabilities.*
- *Joint Biological Remote Early Warning System, Joint Biological Universal Detection System, Joint Biological Point Detection System Block II, Joint Service Warning and Identification LIDAR Chemical Detector, Joint Chemical/Biological Detector and the Chemical Wide Area Detector will require land where these systems can detect and classify chemical and/or biological simulants in actual terrain.*
- *Theater Missile Defense Systems [Theater High Altitude Area Defense (THAAD) and Patriot Advanced Capability Three (PAC 3)], which have extremely large safety and performance envelope requirements due to extended ranges with intercepts at over 100,000 feet.*

Navy

- *Joint Direct Attack Munition and Joint Standoff Weapon will significantly increase the range and altitudes at which targets can be attacked, requiring additional air and range areas for testing and training.*

- *Extended Range Guided Munition will incorporate a rocket-assisted projectile and Global Positioning System guidance to provide over-the-horizon Naval Surface Fire Support.*

- *Standoff Land Attack Missile (SLAM/SLAM-ER) is designed for greater standoff attack from F/A-18's and other Navy aircraft against fixed targets and ships in port. The improved SLAM-ER increases the attack range of the missile and will require full use of existing range space.*

- *F/A-18 E/F Hornet Fighter/Attack Aircraft and Joint Strike Fighters will have significantly longer ranges, better performance, and increased survivability– requiring greater area for testing and training.*

- *Ship-board Theater Missile Defense Systems (Navy Area Defense and Navy Theater Wide) have extremely large safety and performance envelope requirements due to ever-increasing ranges of threat ballistic missiles and friendly interceptors with intercepts at over 100,000 feet. These systems must also be tested under a simultaneous multiwarfare scenario, i.e., anti-air warfare, anti-submarine warfare, and anti-surface warfare.*

Air Force

- *Airborne Laser, representing the first operational directed-energy weapon and the only boost-phase missile defense system, will require a significant safety footprint to test and evaluate all operational parameters.*

- *Evolved Expendable Launch Vehicle now involves the development of a family of launch vehicles and will thus require more numerous tests, with added emphasis on environmental concerns, than initially planned.*

- *F-22 Advanced Tactical Fighter, the next-generation Air Dominance fighter, has the capability to fly higher and faster than current F-15 aircraft; and stealth, supercruise, high agility, integrated avionics, data fusion, and thrust vectoring characteristics.*

- *Joint Air-to-Surface Standoff Missile is designed to attack heavily defended targets with high precision at great standoff distances.*

- *Predator, Global Hawk, and DarkStar are designed to be long-range, long-endurance unmanned reconnaissance vehicles operable at various altitudes.*

- *Space-Based Infrared Systems, a system of advanced infrared sensing satellites to replace the aging Defense Support Program satellites, will perform the four space surveillance missions of missile warning, theater and national missile defense, battlespace characterization, and technical intelligence.*

- *Sensor Fuzed Weapon, a wide-area anti-armor cluster munition, is designed for use by fighters and bombers for multiple kills per pass.*

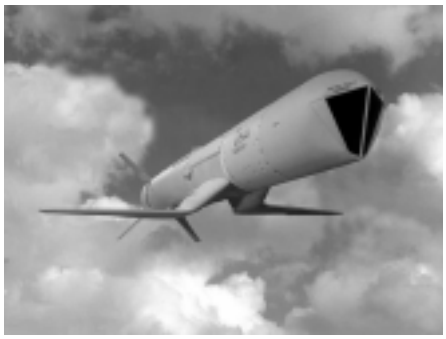
Marine Corps

- *AAAV, a larger, faster, and more capable amphibious assault vehicle than its predecessor, is designed to maintain pace with the main battle tank after it swims ashore. It is being designed to support Operational Maneuver from the Sea (OMFTS) and Ship to Objective Maneuver (STOM).*
- *V-22 Tilt Rotor Aircraft is an entirely new platform encompassing tilt rotor technology and offering longer range. It will replace the outdated CH-46 helicopter with a more capable aircraft that will also support OMFTS and STOM.*

Figure 1. Weapon Systems Under Development.

U.S. Air Force F-22 Raptor

V-22 Tilt Rotor Aircraft



Standoff Land Attack Missile (SLAM-ER)

ATACMS Block II/Brilliant Anti-Armor Submunition

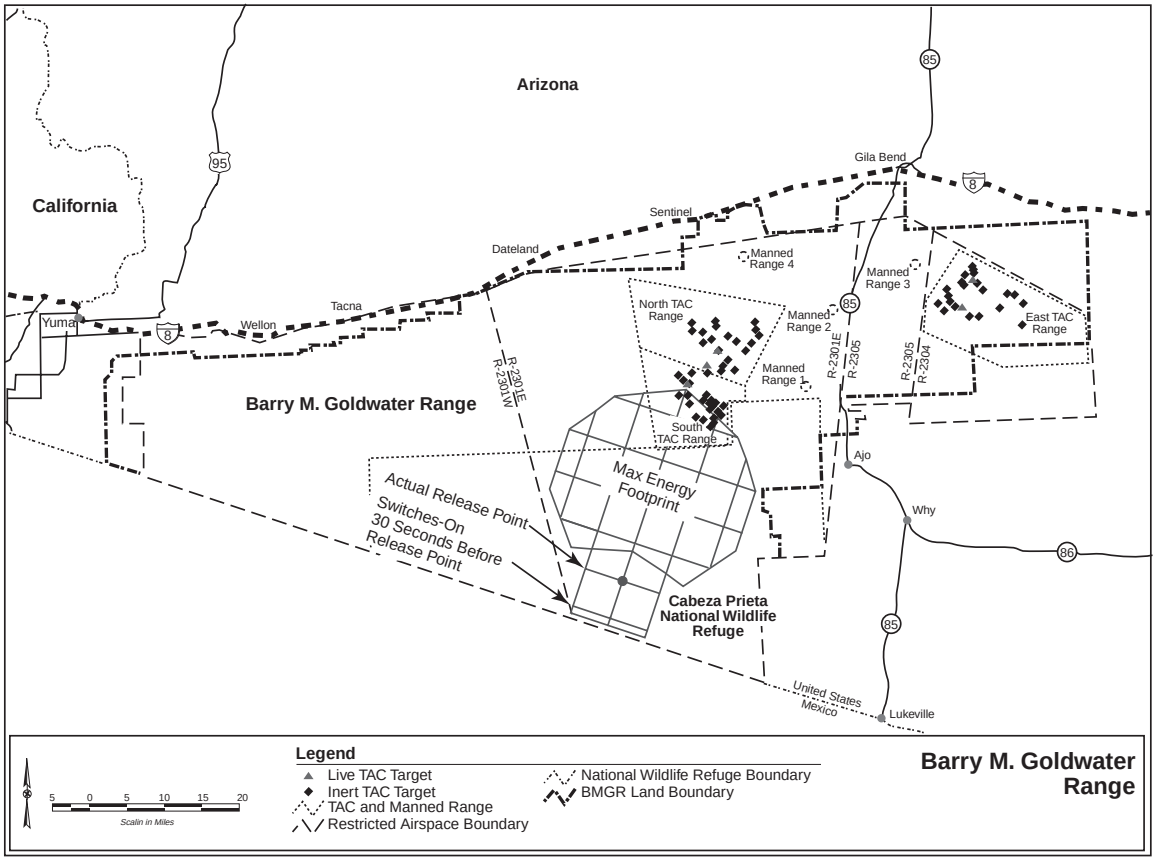
Safety

For safety reasons, the DoD requires test articles, including debris, to remain within range boundaries, if possible. For each weapon system, a safety footprint is developed that shows the maximum distance the weapon could travel after launch. The size of the footprint depends on such variables as launch altitude and attitude, the total energy of the weapon, guidance performance, and whether the weapon contains a flight termination system. For weapons without a flight termination system, testers have little or no control over the weapon once it has been launched. While the ability to predict an impact point improves as the weapon system progresses through development, the predictability of some weapon systems remains small. Therefore, ranges must use the most conservative safety footprint during early development and even into training.

Safety is a primary underlying consideration for both testing and training range size and shape. Realistic testing and training with advanced weapon systems requires expansive land areas for safety reasons. Although modern guided weapons are more accurate and produce less collateral damage, they may have a larger safety footprint to provide adequate safety distances in the event of a malfunction. This is illustrated in Figure 2, which depicts the maximum energy footprint for the Joint Direct Attack Munition overlaid on the Air Force's Barry M. Goldwater Range. The fundamental purpose of a range, like the Barry M. Goldwater Range, is to reserve a land area corresponding to weapons' maximum energy footprints to ensure public safety.

Another example of space requirements for modern weapons is a laser-guided bombs (LGBs) which employs a standard free-fall bomb with a laser seeker on the nose and movable fins for control. The addition of the movable fins causes the LGB to have a safety footprint larger than the free-fall bomb. When mated to a rocket booster, the LGB has an extended operational range and thus the range safety footprint increases dramatically. To perform development and operational tests, the range used for testing has to be of sufficient size to contain the entire safety footprint.

Figure 2. Barry M. Goldwater Range: *This figure depicts the Barry M. Goldwater Range overlaid by the maximum energy footprint for the Joint Direct Attack Munition.*



Security

Secure ranges are required to deny foreign and unauthorized entities knowledge of sensitive programs. The availability of large, remote ranges enables the Department to maintain security during test and training exercises. During the development and testing of advanced systems, it is crucial to mask certain system aspects and capabilities from foreign entities. If a foreign entity were to become aware of new systems or modifications to systems prior to their deployment, it would encourage them to modify the threat to counter our advances and negate any benefit that may have been gained. Additionally, the United States may obtain foreign systems to aid in understanding threat capabilities and vulnerabilities and assist in developing countermeasures and tactics. If the foreign developer or foreign entities that purchased the system

become aware of our possession of these systems, it could hasten the modification of threats and possibly negate U.S. countermeasures.

Environment

U.S. military systems must be effective and suitable in all environments; therefore, U.S. ranges must offer the capability to test systems in all types of environmental conditions, including extreme cold, desert, tropic, and temperate climates.

Another aspect of the testing environment involves the features a particular location might offer that could help (or hinder) testing of weapons such as supersonic aircraft technologies, associated munitions, and space systems. For example, the Special Weapons Center was established at Kirtland Air Force Base, New Mexico because of the concentration of technologies and industries supporting nuclear weapons development in the region. DoD also constructed a high-speed sled track, a navigation/guidance facility, and radar cross-section test capabilities in New Mexico because of the need for specific seismic stability, isolation, and electronic quietness only found in this region of the country. Space and ballistic missile testing requirements, including both polar and equatorial orbital options, created the need for both West and East Coast launch complexes to provide launch windows over ocean rather than populated areas. Electromagnetic interference testing requires an isolated area with relatively low ambient radio frequency (RF) level.

TRAINING

Training requirements for ranges and training areas are primarily influenced by the type of training, warfighting doctrine, and the element of the force being trained. There are several types of training including joint, component interoperability training, and Service training. Joint training is based on joint doctrine to prepare joint forces and/or joint staffs to respond to operational requirements deemed necessary by combatant commanders to execute their assigned missions. Component interoperability training is based on joint doctrine or joint tactics, techniques, and procedures in which more than one Service component participates. This training is normally designed to improve

responsiveness of assigned forces to combatant commanders. Component interoperability training is conducted under the auspices of a component commander. The purpose is to ensure interoperability of combat, combat support services and military equipment between two or more Service components. Service training is based on Service policy and doctrine to prepare individuals and interoperable units. Service training includes basic, intermediate, advanced, and component-sponsored interoperability training in response to operational requirements deemed necessary by the combatant commands to execute assigned missions.

These types of training differ in terms of numbers of participants, goals, and complexity. These factors influence requirements for ranges and training areas. Joint training provides a framework for integrating core Service-training programs—both individual and collective. Service training develops proficiency in the specific skills and capabilities the Military Services bring to the joint arena. Service training requirements differ among the Military Services because of their different roles and missions. However, each Service requires support for three levels of training—basic, intermediate, or advanced.

Basic training generally involves repetitive performance of basic procedures and is typically conducted in a benign threat environment. Much of this type of training takes place at so-called “primary” training ranges at the installations where units are based.

Intermediate training combines the elements of basic training into coordinated engagements in a simulated threat environment. This level of training typically involves mission planning (selecting the appropriate tactics and weapons systems to employ) and the fusion of data from multiple sensors to achieve threat recognition and response. Most intermediate training can be accomplished at larger installations.

Advanced training combines all the elements of intermediate training into coordinated large-scale, multi-warfare missions in a high-stress combat/threat environment. Examples include coordinated Air Wing Strikes, amphibious assault exercises, and full-scale joint force operations. Only a few ranges and training areas are of adequate size and have the proper terrain, environmental conditions, and instrumentation necessary to support advanced training.

The remainder of this section discusses the specific factors associated with joint training and each Military Service's component training requirements.

Joint

Exercise objectives, component training requirements, and weapon engagement distances are the primary factors influencing requirements for ranges and training areas to support joint training. To determine exercise objectives, Commanders In Chief (CINCs) analyze war plans to determine joint mission essential tasks that their forces must be prepared to execute. CINCs establish exercise objectives to enable participants to build and sustain proficiency in the doctrinal execution of these joint mission-essential tasks. Component training requirements are then factored in along with weapon engagement distances. Exercise planners consider exercise objectives, component training requirements, and weapon system engagement ranges when developing requirements for ranges and training areas. Joint training exercises that occur in the United States rely on use of Military Service ranges and training areas.

Army

The Army's operational force structure consists of units in the Active Component (AC)—the Active Army—and in the Reserve Component (RC)—the Army National Guard (ARNG) and U.S. Army Reserve (USAR). The principal elements of the operational force structure are 10 AC divisions, 14 RC divisions, and 15 ARNG Enhanced Readiness Brigades.

Of the 10 AC divisions, 6 are Armored or Mechanized Infantry, 2 are Light Infantry, 1 is an Airborne Division, and 1 is an Air Assault Division. The "heavy" divisions (Armored and Mechanized Infantry) contain Bradley Fighting Vehicles, Abrams Tanks, and associated weapons systems. The vehicle density in these units is high, with all components of the division equipped with highly mobile, often tracked, vehicles. The light divisions (10^{th} Mountain Division, 82^{nd} Airborne Division, and 101^{st} Airborne/Air Assault Division) are normally configured with 9 infantry battalions and corresponding aviation and support units. There are no tracked vehicles in the light divisions. The Airborne Division has a parachute assault capability. The Air Assault Division includes extensive aviation

(helicopter) capability to maneuver the ground combat and support units on the battlefield. RC divisions are a mix of heavy and light units, organized identically to those in the AC. The 15 ARNG Enhanced Readiness Brigades are combined arms teams consisting of a self-contained mix of maneuver, combat support and combat service support units. Hundreds of other AC and RC units are organized to perform combat, combat support and combat service support tasks and missions on the battlefield.

Operational force structure basing reflects a combination of war plan orientation and historical precedent. During the Cold War, the preponderance of heavy forces were forward deployed in Germany. Since then, the majority of Army operational forces have been based in the continental United States. The Army built the installations housing these units during World Wars I and II. However, there has been significant fluctuation in base structure—expansion for World War II, the Korean War, the Vietnam War; profound reduction following World War II; and more gradual reduction after the end of the Vietnam War and the Cold War. The Army has retained those installations that best support a combination of infrastructure, deployability, and training needs. In the United States, operational units are generally based on divisions or larger formations.

RC unit basing is dispersed and varied. Individual units as small as companies and battalions are “based” at armories or centers on AC and RC installations or in civilian communities. Armories and centers are not true bases and do not normally include any significant land for ranges and training areas; therefore, they support only limited training. However, the RC also controls some installations with ranges and training land where training beyond the level possible at armories and centers can be conducted.

The Army also consists of non-tactical structures. The most significant of these, from a training perspective, are the branch Service schools assigned to the U.S. Army Training and Doctrine Command (TRADOC). Each Service school is organized to conduct a range of institutional training courses for the soldier, non-commissioned officer, warrant officer, and officer. Each TRADOC installation supports the type of individual and professional development training required of that branch. The majority of Service school bases have remained stable over the past 40 years.

The Army advances national military policies through its unique capabilities for conducting sustained land combat that controls land, resources, and populations. Those capabilities are evidenced in the Army's ability to fight and defeat large enemy ground combat formations as well as to execute a broad range of missions, such as combating terrorists, providing humanitarian assistance, peacekeeping, and helping with domestic disaster relief.

Army units train as combined arms teams in order to be prepared to carry out doctrinal missions. Specific units are organized by branch designated as a combat arm, combat support arm, or combat service support. To form combined arms teams, units are "cross-attached" to create self-sustaining unit combinations with multiple combat, combat support, and combat service support capabilities. Army divisions are combined arms formations and are assigned to corps that can be organized to provide the mix of type and size units required for any ground combat mission.

Training to support Army doctrine is categorized as either individual or collective. Individual training is conducted in the TRADOC branch service schools. Individual training consists of Initial Entry Training for new soldiers, and job-specific technical training. Individual training is required for any member of the Army to carry out his or her specific tactical and technical tasks. Initial Entry Training for soldiers begins with basic combat training, followed by advanced individual training. Basic combat training is uniform for all soldiers. Advanced individual training reflects the diversity in job types and skills across the Army structure. Individual training for officers, warrant officers, and non-commissioned officers is branch based. It consists of a hierarchy of courses that develop the technical, tactical, and leadership skills of individuals based on the tasks unique to their branch of the Army.

Collective training is an essential element of Army readiness. Collective training combines the soldier and leader products of the individual training system into units and gives them weapon systems to form combat-ready teams. Operational units conduct collective training. Collective training ensures that unit teams are capable of performing their combat, combat support, and combat service support battlefield missions and tasks to doctrinal standard.

The majority of collective training is conducted at home stations at squad/crew, platoon, company, battalion, and brigade levels. Training at the Army Combat Training Centers (CTCs) is the capstone of collective training. The Army operates three CTCs. Each is capable of supporting Brigade Combat Team rotational training events. CTCs include a staff of trained and experienced "observer/controllers" who assess unit performance and provide feedback to units undergoing training. Each CTC also consists of a permanent "opposing force" capable of portraying potential adversaries. The three CTC "battlefields" at Fort Irwin, California; Fort Polk, Louisiana; and Hohenfels, Germany, are uniquely equipped to provide a degree of training realism and assessment not possible at a unit's home station.

Navy

By the year 2002, the Navy's force structure will include 12 active aircraft carriers and 116 surface combatant ships. The number of surface combatants will be reduced from today's level of 128 as newer and more capable systems are added to the fleet. The number of carrier air wings will remain at 10 active wings and 1 reserve. Each carrier air wing is a mix of fighter and bomber aircraft, tactical support aircraft, and multi-mission helicopters. The Navy's range requirements come from upgrades to aircraft, ships, submarines, range targets, and threat simulators; new weapon platforms; and carrier air-wing training needs.

U.S. Navy training begins with the individual, and evolves to include more complex, interoperative units. For example, in the case of the carrier-based squadron, the air crewman first qualifies in aircraft type. The next step is an intensive air combat training program. Single or small-group flights deploy to ordnance and weapons delivery, air combat maneuvering, and electronic combat ranges to refine skills. As proficiency increases, the operational units increase in size and complexity. Squadron-level training missions lead to full carrier air-wing training. Flying out of locations such as Fallon, Nevada, massed sorties of attack, fighter, early warning, and electronic combat aircraft conduct coordinated air wing strikes.

These complex operations lead to "graduation" exercises, after which the air wing becomes "ship's company" aboard an aircraft carrier. The carrier is the centerpiece of the carrier battle group that includes smaller combatant and

support ships of various types. Most battle group training exercises are conducted some distance from the shores of the United States. Amphibious landing group exercises, however, are conducted in littoral waters off Camp Lejeune on the East Coast and off San Diego on the West Coast.

The end product is a fully trained battle force, ready to fulfill the Navy mission to project military power as a Naval Expeditionary Force.

Air Force

The Expeditionary Air Force (EAF), an innovative approach to meeting the challenges of the new global security environment, will employ ten Air Expeditionary Forces (AEFs) with like capabilities that ensure light, lean, and lethal air and space total force packages tailored to meet the needs of a joint force commander. An EAF is defined as "a vision for how to organize, train and equip to create a mindset and cultural state that embraces the unique characteristics of aerospace power—range, speed, flexibility, precision—in all that we say and do." The AEF is "the tool that implements the EAF strategy and provides warfighting commanders with rapid and responsive aerospace power, tailored to meet specific needs across the spectrum of response options from humanitarian relief to combat operations." To guarantee an Aerospace Force ready to meet current and future engagement requirements, AEFs and supporting elements need ranges to maintain proficiency and also to support evaluation of advanced weapon systems.

Air-training ranges are needed to support aircrew training. Each aircrew member must train in the individual skills of the basic weapon. This requires a strike target; a conventional target; and a surface attack tactics array with suitable targets, including infrared targets and electronic combat training. Aircrews must also get flight-level training that includes coordinated multiple-aircraft attacks flown against a surface-attack array of multiple targets. Finally, aircrews must train at the wing level with joint forces that could include up to 100 aircraft. This requires a very large area of airspace with multiple-surface attack target arrays, plus an integrated air-defense system of electronic combat emitters, electronic countermeasures feedback, weapons scoring, tactical strafe, live and inert weapons drops, and full force-on-force training.

Marine Corps

The projected force structure of the Marine Corps will remain basically constant well into the 21st century. The Marine Corps will include three active and one reserve divisions, plus three active and one reserve aircraft wings.

Marine Corps combat units are organized into combined arms teams called Marine Air Ground Task Forces. The largest of these, the Marine Expeditionary Force (MEF) has four elements: the command element, which provides command and control for the force; the ground combat element, an infantry division; the aviation combat element, an aircraft wing; and the combat service support element, a force service support group. The Marine Corps uses the MEF as the baseline unit for determining training requirements. There are three MEFs, I MEF on the West Coast; II MEF on the East Coast; and III MEF in Japan.

A MEF requires ranges and training areas across a broad spectrum of geography and environment to continue, expand, and enhance training of individual marines. Such training includes individual weapon and military occupational specialty; infantry units in tactics, fire, and maneuver; aviation units in aerial combat, close air support, and assault support; and combat service support units in the logistics functions supporting the MEF. The entire MEF is coordinated during combined arms exercises that include all aspects of combat employment.

Marine Corps Bases exist not only to provide range and training support to the fleet marine forces, but also to support formal schools that train marines in combat skills on their way to the fleet marine forces. The infantry schools, staff non-commissioned officers and non-commissioned officers academies, field medical school, various assault vehicle schools, and weapons and field training battalions at the recruit depots, to name a few, all utilize ranges and training areas. Any range assessment must include consideration for the resources required for formal training.

JOINT EXPERIMENTATION

Joint Experimentation is a new DoD program aimed at exploring, demonstrating, and evaluating joint warfighting concepts and capabilities required to implement Joint Vision 2010 and beyond. The U.S. Atlantic Command is responsible for executing this iterative program which involves the collection, development, and exploration of concepts to identify and recommend the best solutions for changes to military doctrine, organization, training and education, materiel, leadership, and people required to achieve significant advances in future joint operational capabilities. Joint Experimentation integrates technologies under test, alternative forces, and concepts in realistic field environments against the full range of future challenges to assist DoD in developing and validating new joint warfighting concepts.

The Joint Experimentation program will include analyses, simulations, war games, experiments, advanced concept technology demonstrations, and joint exercises conducted in virtual and field environments. Several of these program elements will necessitate the use of ranges and training areas. Joint Experimentation requirements for ranges and training areas will be driven by factors similar to those for testing and training—weapon system performance, safety, security, size of the force, and doctrine.

IV. CURRENT AND FUTURE REQUIREMENTS

Our military forces require land, sea, and air ranges and training areas for testing weapon systems, deploying these systems, and conducting combat training. DoD's current ranges and training areas generally reflect these requirements; however, continued changes in the defense environment require DoD to continuously reevaluate its ranges and training areas.

Table 2 provides some perspective on the typical applications of ranges and training areas and indicates the users for those applications. Appendix A provides a list of specific major ranges and training areas, including their typical uses.

Table 2. Applications of Ranges and Training Areas.

Typical Range/Training Area Applications	User			
	Army	**Navy**	**Air Force**	**Marine Corps**
Aircraft Testing	X	X	X	X
Aircraft Systems Testing	X	X	X	X
Air Combat Maneuvering	X	X	X	X
Air-to-Air/Air-to-Ground Weapons	X	X	X	X
Amphibious Assault Maneuver		X		X
Anti-tank Weapons	X		X	X
Artillery/Mortar	X	X		X
Ballistic Missile Defense	X	X	X	
Close Air Support	X	X	X	X
Combat Vehicles	X			X
Demolition/Explosives	X	X	X	X
Electronic Combat	X	X	X	X
Ground-to-Air Missiles	X	X	X	X
Ground-to-Ground Missiles	X	X	X	X
Heavy Equipment Operations	X	X		X
Helicopter Gunnery	X	X	X	X
Infiltration Courses	X	X		X
Ground Exercise	X			X
Laser Targeting	X	X	X	X
Marksmanship Training/Proficiency	X	X	X	X
Non-lethal Weapons	X		X	X
Nuclear, Biological, Chemical Defense	X	X	X	X
Parachute Drop Zones	X	X	X	X
Space Systems			X	
Tank Gunnery	X			X
Urban Warfare	X			X

Because the Military Services have many common requirements for ranges and training areas, many of the current ranges and training areas support more than one Military Service for both testing and training. Specific examples include the Goldwater Range, which supports the Marine Corps and the Air Force; Fort Greely and Fort Wainright in Alaska, which support the Army and the Air Force; and the installations that make up the Major Range and Test Facility Base, which are available to support all of the Military Services.

CURRENT REQUIREMENTS TO SUPPORT TESTING

The Department of Defense needs a combination of highly complex and capable facilities and ranges to support testing of weapon systems under development as well as in production. These facilities and ranges are used to collect data needed to validate system design and performance and to determine system effectiveness, suitability, survivability, and military utility. DoD's current requirements for ranges and training areas to support testing are described by functional area below.

Land Systems

Testing of land systems addresses the individual soldier, and the soldier's equipment, and land vehicles, including systems and subsystems of self-propelled and towed vehicles. Land systems must withstand the elements of transport and transit and still accomplish their mission. The effectiveness, suitability, and survivability of these systems is dependent on mobility, fire power, inherent signatures, reliability and maintainability, vulnerability, and countermeasure tactics, all of which require extensive testing for system development, maturation, and deployment.

To support testing of these systems, DoD ranges must be capable of accommodating the operational characteristics and data-collection requirements of the advanced technology land weapon systems of the future. Range requirements include all types of terrain and vehicle obstacle courses, a spectrum of climates, and range distances that will permit maneuver, direct-fire, and indirect-fire of long-range armaments with absolute safety.

Sea Systems

Sea systems include surface and sub-surface maritime platforms of all sizes to support all DoD maritime missions. This includes all naval surface ships, submarines, boats, barges, unmanned self-propelled surface and subsurface craft, surface and subsurface fixed systems, and airborne, surface, and subsurface anti-submarine warfare systems.

Ranges must be configured for air, land, sea, and undersea testing of sea systems to allow for effective data collection, safety of operations, and replication of naval operational conditions. Range areas must provide the sea space to test all of the performance and operational capabilities of the DoD sea systems. The DoD test range complex must also have available sea space with associated air space and adjoining land space to permit testing of the complex command, control and communications systems of modern sea systems with the complementary land and air forces.

Air Systems

Ranges are required to support testing of DoD air systems, including all manned fixed-wing (sub-, super-, and hypersonic), unmanned air vehicle, and rotary-wing aircraft. Air systems include subsystems requiring testing including airframe, avionics, fire control, propulsion, command and control, and human systems. Air-systems testing involves testing of the entire aircraft system—the air vehicle, on-board subsystems, aircraft stores compatibility, aerial delivery, and system and subsystem software—as well as modifications and upgrades.

Air system testing requires complex ground testing facilities as well as extensive air space for conducting major flight testing programs. Air systems testing requires air, land, sea, and space ranges. In all cases, complex instrumentation is required to obtain performance data for aircraft systems, data for evaluation of operational effectiveness and suitability, and system information on interoperation with other forces. These complex instrumentation systems require sufficient frequency spectrum to ensure successful operations and non-interference from other public and private emitters. Ranges and test facilities are required to test aircraft flying qualities and performance, ground test of installed and uninstalled engines, electronic combat, electromagnetic performance, and

weapon separation, as well as special characteristics such as carrier suitability and compatibility with catapult and arresting gear.

Armament and Munitions

Testing of armament and munitions involves all weapons, weapon delivery launchers and munitions, including: nuclear, conventional, directed energy weapons, and weapons launched from air, sea, and land. Weapons include torpedoes, mines (land and sea), bombs, guided bombs, missiles, guns, hand guns, rifles, automatic hand weapons, rockets, grenades, and ammunition. Weapon subsystems include platform, guidance, warhead, fuse, seeker, and propulsion.

DoD requires ranges capable of accommodating the firing and data-collection requirements of the advanced technology armament and munitions systems of the future. Current requirements for land and air space are largely driven by the performance and range of missile-launched weapon systems, sophisticated multiple warhead systems, and the safety envelopes that must be provided to accommodate these tests. Another component of armament and munitions testing, which applies to other types of systems as well, is the need to test the weapons to ensure they are suitable and effective in all climatic and geographic environments.

Electronic Combat Systems

Electronic combat (EC) systems include all systems that use electromagnetic and directed energy to control the electromagnetic spectrum or to attack the enemy. This includes systems that can be used from or to air, sea, and land. The functions of electronic attack, electronic protection, and electronic support are included. Electronic attack includes suppression, electromagnetic jamming, and electromagnetic deception. Electronic protection includes protection of personnel, facilities, and equipment from any effects of friendly or enemy employment of electronic combat intended to degrade, neutralize, or destroy friendly combat capability. Electronic support includes missile warning and receivers to intercept, identify, and locate sources of intentional and unintentional radiated electromagnetic energy threat warning. EC systems or subsystems may include dedicated sensors, equipment, communications and

platforms that stand alone or co-exist and interface with other military systems. An EC system or subsystem includes all of the hardware, computers, software, network links and lines where applicable, up to the interface with other military systems.

Testing of electronic combat systems requires land, air, and sea space that are requisite for the platform that is carrying the EC system and the platforms representing the threat systems and targets. All elements of EC including RF, electro-optical, infrared, and high power microwave can cause interference in private signals and conversely the private signals can disrupt the sensors used for testing and training. To ensure there is no interference from public or private RF systems, extended land, air, and sea range areas are needed. In addition, some testing of EC systems requires a level of security that results in the requirement for additional distance from sites of potential observation or monitoring.

Command, Control, Communications, Computers and Intelligence (C4I) Systems

C4I includes command and control, communications, computers and intelligence either as integrated systems or subsystems. The command and control system or subsystem includes the equipment, communications, procedures, and personnel essential to a commander for planning, directing, and controlling operations of assigned forces for all assigned missions. It includes Air Traffic Control and water space management. The communications system or subsystem includes the equipment and personnel essential to receive and transmit information to military systems on all military platforms as required. Such a system provides an accurate, complete, and timely picture to support effective command and control.

C4I includes those computers, software and architecture that are organic to its subsystems or the total integrated C4I system. The intelligence system or subsystem includes the equipment, procedures, and personnel essential to obtain, process and interpret data from foreign countries and adversaries, in order to provide reasonable judgments to decision makers. C4I includes the surveillance and reconnaissance systems or subsystems that collect data and information from all sources to provide continuing support to the command,

control and intelligence function and other levels of decision making. It includes all of the systems or subsystems up to the interface with other military systems.

Since C4I systems or subsystems can be mounted or distributed in air, sea, land, and space platforms, the area required to conduct appropriate C4I testing is related to the air, land, and sea space area requirements for the platforms. An additional requirement for realistic testing of long-range C4I systems is that the testing must be conducted over an extended area that is comparable with the intended operating ranges of the C4I systems when employed. For adequate testing of C4I systems intended for operation by large force arrays, land, air and sea space requirements increase to permit the gathering of realistic forces to demonstrate the capability of the C4I system. Similarly, the controlled frequency spectrum required for large-scale C4I testing also presents a demanding requirement.

Space Systems

Space systems include manned and unmanned space vehicles, launch vehicles, and ground support systems. Space vehicles include mission payloads, propulsion, structures, integration, power and conditioning, and guidance and control. Launch vehicles include structures, propulsion, and guidance and control. Ground support subsystems include tracking, telemetry, and control as well as launch vehicle support. Range requirements include vehicle preparation and launch sites and associated safety buffer zones, airspace for launch trajectories, and tracking stations.

Space systems testing requires launch complexes and ranges that provide instrumentation systems to gather testing and performance data for the system under test, as well as tracking systems and safety footprints (air and ground space) to ensure the safe conduct of the testing operation. After launch, space systems rely on control systems that must be tested in a controlled environment with appropriate frequency spectrum.

Ballistic Missile Defense Systems

Ballistic Missile Defense Systems include both theater missile defense (TMD) and national missile defense (NMD) systems. TMD systems have a radar, propulsion system, guidance and control section, seeker, warhead, and

extensive battlefield management C4I systems that must be tested piece-by-piece and as an integrated system. NMD consists of a ground-based interceptor and a ground based radar. The ground-based interceptor consists of many of the same components as the TMD systems with the addition of an exo-atmospheric kill vehicle.

Ballistic missile defense systems testing presents unique requirements to test systems that defend against ballistic missiles with ranges varying from several hundred up to many thousand kilometers. The long distances and large safety footprints (launch safety zones, booster drop zones, and possible debris impact zones) of threat missiles, surrogate targets, and defensive missiles require extremely large test ranges and associated land, sea, and air space. Ballistic Missile Defense testing requires vast expanses of unpopulated or sparsely populated range space, over land or over water, due to the capability of both the threat ballistic missiles and the ballistic missile defense systems. The Navy shipboard TMD systems require sea test ranges. NMD testing requires much longer ranges with similar capabilities. The Airborne Laser (ABL) will require areas where low altitude, boost-phase destruction by high-energy laser can take place.

All require ranges with extensive and highly sophisticated instrumentation (i.e. telemetry, time, space, position instrumentation, endgame monitoring, command-destruct capability) to evaluate the test and for debris tracking and assessment. In addition, treaty compliance considerations must be taken into account.

Much of this testing can be done at less than the maximum ranges of the threat missiles and the systems under test. However, maximum range scenarios must be included within the test program to have a high degree of confidence that the system will work in the extreme operational setting.

Over land requirements for actual firings exist for ballistic missile defense testing. A relatively clear and unpopulated flight corridor from launch site to impact range is needed in consideration of where separating boosters will fall. Many of the ballistic missile defense system’s early and shorter-range intercepts can be tested over land at costs lower than those for over-water testing. In addition, establishing remote launch sites at a non-contiguous range space can

expand the capability of land ranges. This approach requires a rather large launch area to accommodate the required launch safety footprint as well as the launch instrumentation, tracking, and data systems.

There are times when ballistic missile defense system capabilities and the requirements to test them exceed the Department's land ranges and training areas. The only currently feasible alternative to land-based test ranges is over-the-water test ranges such as Vandenberg Air Force Base's Western Range, the Naval Air Warfare Center Weapons Division's Sea Range, the Pacific Missile Range Facility, and the Kwajalein Missile Range (KMR). Sea ranges provide relatively encroachment-free areas over which missile destruction debris can safely fall.

Only two sites for testing a national missile defense system are compliant with the Anti-Ballistic Missile Treaty—White Sands Missile Range in New Mexico and Kwajalein Missile Range in the Marshall Islands.

CURRENT REQUIREMENTS TO SUPPORT TRAINING

Dedicated ranges and training areas are essential to training military forces in the doctrine, tactics, techniques, and procedures necessary to accomplish the wide variety of military missions U.S. forces must perform. A robust combination of maneuver ranges for all sized units and firing ranges for the weapons appropriate to those units is essential to combat readiness. Available land area does not exist at each base to accommodate all types of training, but suitable areas must be made available for forces of all types within a reasonable proximity.

Also, training areas must provide for training in all environments where U. S. forces are expected to operate. Desert, mountain, forested, urban, jungle, and arctic training areas must be maintained. Live-fire ranges must accommodate direct-fire weapons, mortars, artillery, missiles, and all types of aviation ordnance. U.S. forces must be allowed to practice the types of operations expected before they are put in harm's way.

Although requirements differ somewhat for joint training and among the Military Services for component and inter-Service training because of their different roles and missions, the types of ranges required are similar.

Joint Training and Joint Experimentation

Relatively few Joint Training exercises take place on ranges and training areas within the scope of this report. The exercises that do take place, such as Roving Sands, require ranges and training areas with appropriate environmental conditions, sufficiently large land, sea, and air space to deploy a combination of forces and weapon systems representing both defending and opposing forces. Requirements for ranges and training areas are based on performance characteristics of the weapon systems and the warfighting doctrine employed during the exercise. Requirements to support Joint Experimentation will likely be similar.

The Secretary of Defense designated the U.S. Atlantic Command as the executive agent for Joint Experimentation in May 1998. U.S. Atlantic Command will identify requirements for ranges and training areas to support Joint Experimentation as the program matures. Existing Military Service ranges and training areas will be made available to support the U.S. Atlantic Command in their efforts.

Army

For the Army, land and ranges for training remain essential requirements and assets. Given the factors driving requirements discussed previously, most Army installations with an operational unit and a mission for collective training, Service school individual training, or both, require the following:

- *An array of fixed, small-arms ranges supporting individual and crew proficiency on pistols and rifles, machine guns, anti-tank weapons, grenades, and grenade launchers.*
- *A set of crew-served weapon system ranges supporting tanks, infantry fighting vehicles, artillery, air-defense artillery, and attack helicopters.*
- *One or more impact areas into which all ranges are oriented as a safety measure.*

- *One or more maneuver areas, geographically designated, that are continuously allocated and scheduled for maneuver training events required by units or Service schools.*
- *Other training infrastructure located in maneuver areas to support specific tasks. These include drop zones for parachute training, landing zones for helicopter air assault training, Military Operations on Urban Terrain, "mock village" sites, and so on.*

Navy

Table 3 summarizes the range characteristics required for Navy training.

Position papers co-authored by the Secretary of the Navy, the Chief of Naval Operations, and the Commandant of the Marine Corps redirect the focus of the sea services toward a primary mission of power projection across a beachhead. The aim is to provide a robust and credible forward presence through flexible response and dominant power projection. This mission emphasizes joint Navy and Marine Corps operations in a littoral environment (i.e., near-shore and overland).

Tactical training for this littoral focus must include a stressful, realistic environment, with accurate performance measurement and feedback to master each level of training from basic through advanced. Water- and land-based tactical training ranges are critical to meet this training strategy.

Table 3. Summary of Range Characteristics Required for Navy Training

Training Level	Controlled Space	Targets	Threats	Instrumentation/ Feedback
Basic	Sized by weapon delivery range Support weapon deployment by single platform	Basic target to support weapon targeting/delivery of practice or live weapons Threat environment not required during weapon delivery training	Signal recognition Limited number (1-2) Basic emitters suited to weapon/sensor employed Limited signal fidelity	Weapon impact scoring in target areas Data collection to evaluate weapon delivery Real-time debrief during repetitive operations
Intermediate	Area determined by - Sensor range - Tactical maneuvering for multi-unit coordinated exercise of threat areas	Real and simulated targets Multiple targets in realistic environment Visual fidelity for real targets Sensor significant Expendable ground targets for practice/live ordnance Surface, subsurface, airborne targets for live fire	Coordinated multiple threats Accurate threat replication for sensor/counter-measures employment and targeting	Participant tracking Weapon impact scoring Simulated weapon employment outcome Correlated sensor data collection to access multi-platform coordination Immediate post-exercise debrief
Advanced	Size determined by tactical maneuvers in multi warfare coordinated, multi-platform, area operations	Real and/or simulated targets Variety of full-scale, threat-representative targets in realistic environment Visual fidelity for real targets Sensor significant	High-density real and simulated threats located throughout exercise area Coordinated threat operations	Participant tracking Correlated sensor data collection to assess coordinated engagements Weapon scoring, both simulated and real deliveries Kill removal Immediate post-exercise debrief
Naval Expeditionary Force (NEF)	Size determined by tactical maneuvers in full-scale NEF operations	Real and simulated targets Variety of full-scale, threat-representative targets in realistic environment Visual fidelity for real targets Sensor significant	High-density simulated/ stimulated threat environment Coordinated threats, all-axis	Participant tracking Correlated sensor data collection to assess coordinated engagements Weapon scoring, both simulated and real deliveries Kill removal Immediate post-exercise debrief

Air Force

The Air Force vision of an air and space force requires training ranges and airspace with the operational flexibility, efficiency, and realism necessary to maintain operational readiness while allowing commanders to minimize environmental impacts associated with their readiness training. The Air Force currently requires the following types of ranges.

- *Air-to-Air Ranges—to provide air combat maneuvering airspace with associated instrumentation for tracking and scoring aircraft and simulated missile engagements (live-fire training is done on selected ranges under closely controlled circumstances). The Air Force requires low-altitude training space over land and down to 100 feet above ground level. These types of ranges support training for basic fighter and air combat maneuvers, airborne intercept, and electronic combat.*
- *Air-to-Ground Ranges—to provide airspace for single, multiple, and large-force air-to-ground delivery of weapons, including gunnery practice. Weapons may be live, inert, or simulated, and may range from the most simple "iron bomb" or rocket type to the most sophisticated guided "smart" projectile.*
- *Electronic Combat Ranges—to provide a collection of manned and unmanned radars configured to simulate a particular electronic threat environment that adds threat realism to air-to-surface training and provides a demanding threat environment for the training of electronic combat forces.*
- *Air Combat Training System Ranges—to provide specially instrumented air-to-air ranges with unique capabilities to observe activities real-time and record these activities for aircrew feedback.*
- *Spacelift Ranges—to provide access to space to maintain and develop space capabilities.*
- *Air Refueling Tracks—to support test and training operations.*

Marine Corps

Operational units and Service schools are located on or near Marine Corps installations that contain the ranges necessary to conduct the type of training required to prepare Marines for combat. Listed below are the range requirements for ensuring the combat readiness of the Marine Corps:

- *An array of small arms ranges.*
- *A set of crew-served weapons systems ranges for machine guns, mortars, and the like.*
- *Ranges for tanks, light armored vehicles, assault amphibious vehicles, and artillery.*
- *Aviation ranges that support helicopter and fixed-wing training, including air-to-air, air-to-ground, and electronic combat ranges.*
- *Associated impact areas for all types of ground and aviation ranges.*
- *Geographically designated maneuver areas that are continuously available for recurring training and scheduled exercises required by units and service schools.*
- *Amphibious operations areas with associated beaches and helicopter/vertical takeoff landing zones.*
- *Urban warfare training center for training for military operations in urban terrain.*
- *Other training infrastructure located in training areas to support specific tasks. These include parachute drop zones, landing zones for helicopter assault training, mock villages and towns, and so on.*

MEETING FUTURE REQUIREMENTS

Accurately estimating range needs is one of the keys to maintaining future military readiness. Each Military Service is responsible for determining its specific resource needs for testing newly developed systems and for training basic proficiency skills, the use of new systems, and warfighting doctrine. Although the process for determining future needs is specific to each Service's unique mission requirements, the general approach is functionally similar.

Do the Services have the appropriate test and training space to support their missions today and in the future? This question cannot be properly answered without both a top-level perspective of total need, and an installation-level view of available resources. In this context, availability must consider environmental and other constraints that may influence the amount of range space or training area needed.

Military planners must strike a balance among a variety of factors that argue for either more or less land. In particular, planners are faced with the following considerations:

- *Economic considerations*
  - Reduced budgets
  - Pressure to reduce infrastructure
  - Competition for land and airspace
- *Operational considerations*
  - Areas representative of threat environments
  - Capacity to meet test and training requirements
  - Capacity to support operating tempo
  - Surge capacity in case of national emergency
- *Safety considerations*
  - New advanced weapon systems go faster and further
  - Encroachment of population centers near installations
- *Environmental considerations*
  - Protect natural and cultural resources
  - Carrying capacity of ranges and training areas
  - Noise

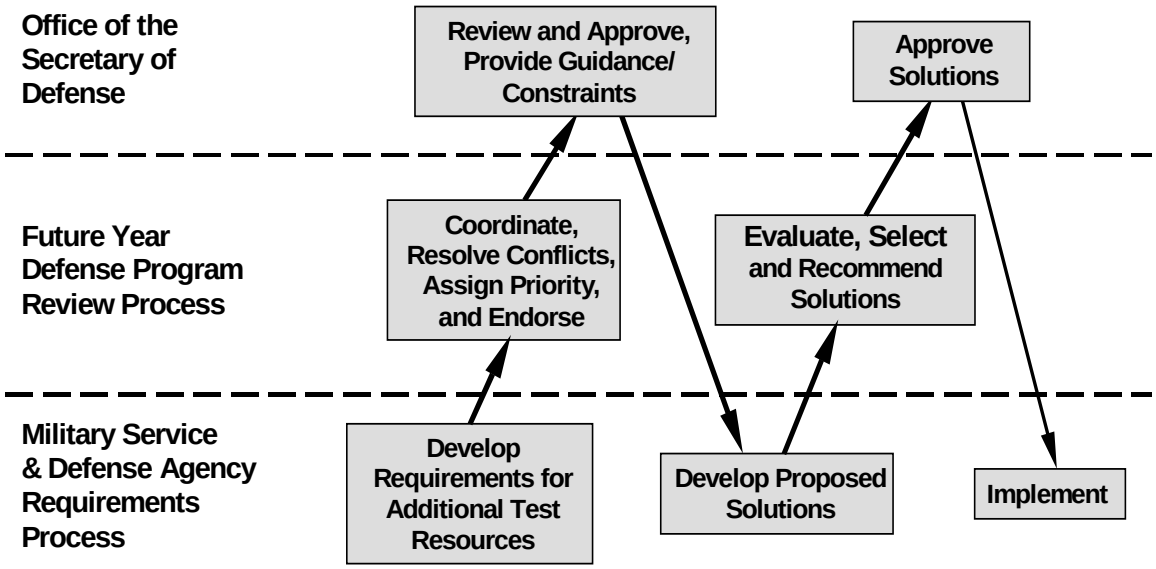
Test Resources

Test resource needs, including those for ranges, are generally determined from the bottom-up. That is, development agencies project their future needs for various types of test resources, the period in which the resources will be required, and the extent to which they will be required for the specific systems

that they are developing. These projections of requirements enable Military Service planners to assess both shortfalls and excess capacity.

The DoD employs a rigorous planning, programming, and budgeting process in the annual preparation of the Future Years Defense Program, the plan that guides all of DoD's operations. Test resource investments are scrutinized, conflicts are resolved, and priorities are assigned at the Military Department/Agency level in this process. The Office of the Secretary of Defense provides guidance to the departments and agencies, reviews their proposed planning and budget solutions, and provides the final approval as appropriate.

Figure 3. Test Resource Coordination Process: *This figure depicts the bottom-up process for determining test resource needs.*

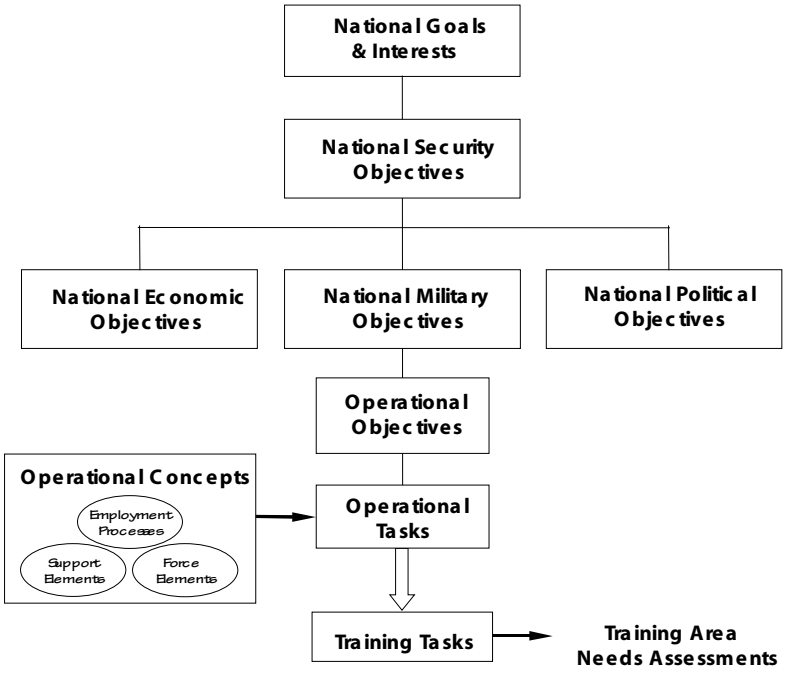


Training Resources

Training resource needs, including those for ranges and training areas, are driven more from a "top-down" perspective. Military Service planners project the amount of training required to achieve mission readiness, which entails maintaining basic skills as well as attaining proficiency with new systems and the latest operational concepts. Since training is keyed to mission requirements, which are in turn driven by national military strategies and goals, a "strategies-to-task" relationship is used to formulate training plans.

In addition to projecting Service-specific requirements for training space, Military Service planners are responsive to guidance from the Chairman of the Joint Chiefs of Staff relative to training objectives that must be accomplished to support joint warfighting operations. For this purpose, the Joint Staff publishes a Universal Joint Task List. This document provides Military Service planners with guidance on the training tasks that must be accomplished, as well as a framework for tracing training events to the mission-based capability requirements they are designed to support.

Figure 4. Strategies-to-Training Task Relationships: *This figure depicts the thread of the strategy-to-requirement flow.*



Once the top-down guidance of Military Service planners has been promulgated, installation commanders must accomplish a bottom-up process to ensure that the requisite training can be supported at the locally available ranges and training areas or, if there is a shortfall, for taking action to acquire other assets. Each Military Service implements its bottom-up process somewhat differently. One example is discussed below—the Army approach.

The Army uses two specific processes to identify land and fixed-range requirements. For land, an Army installation develops a Land Use Requirements Study. The Land Use Requirements Study is an assessment of land required to support all training on a given installation. To complete a Land Use Requirements Study, an installation staff identifies all land users (units, schools, etc.) and applies to each the appropriate Army doctrinal land requirement derived from Training Circular 25-1. The resulting total installation land requirement is compared to assets on hand. The installation uses any deficit as the basis of a land acquisition (or retention, in the case of withdrawals) action.

For fixed firing ranges, an Army installation develops a Range Development Plan based on a standard methodology known as the Range and Training Land Program Generic Methodology. Using that methodology, the installation again identifies all range users (units, schools, etc.) and applies doctrinal range-firing requirements for each. Those requirements come from the Standards in Weapons Training contained in Department of the Army Pamphlet 350-38, and the Army range standards contained in Training Circular 25-8. Once the requirements are identified, a comparison is made to assets on hand. A range deficit becomes the basis for an action to upgrade or build a new fixed range.

The Army has long recognized that its special training requirements have a unique impact on sustained use of land. It also fully recognizes its obligation to sustain and maintain its land in accordance with applicable Federal and State environmental statutes. For those reasons, the doctrinally based requirements for land and ranges are not the total requirement. The Army accounts for sustained land use by means of a deliberate land management process called the Integrated Training Area Management (ITAM) program.

ITAM components provide installations with the capability to assess land condition. The ITAM process applies a “carrying capacity” methodology that accounts for the “load” of unit and service school training programs against the ecological setting of each installation. ITAM supports decision making about land use allocation and scheduling, and, ITAM provides for repair of maneuver damage. The ITAM process may require an installation to set aside a parcel of

land temporarily for recovery or repair, or to reduce or limit the amount and type of training conducted on a particular parcel.

To comply with environmental statutes, the Army, at some locations, is required to set aside permanently parts of its training land in accordance with compliance plans. Both ITAM and environmental compliance generally increase the Army's doctrinal requirement for land as calculated for a given installation. Socioeconomic factors may also affect land requirements. Given the increase in civilian population near Army training installations, there is much greater public awareness of some of the secondary effects from Army training. Noise from weapons and equipment operation, dust from maneuvers, and flares and pyrotechnics used at night may affect people off post, resulting in concerns and complaints. For those reasons, the Army must account for a training land footprint larger than the core doctrinal requirement.

Joint and Multifunctional Use of Ranges and Training Areas

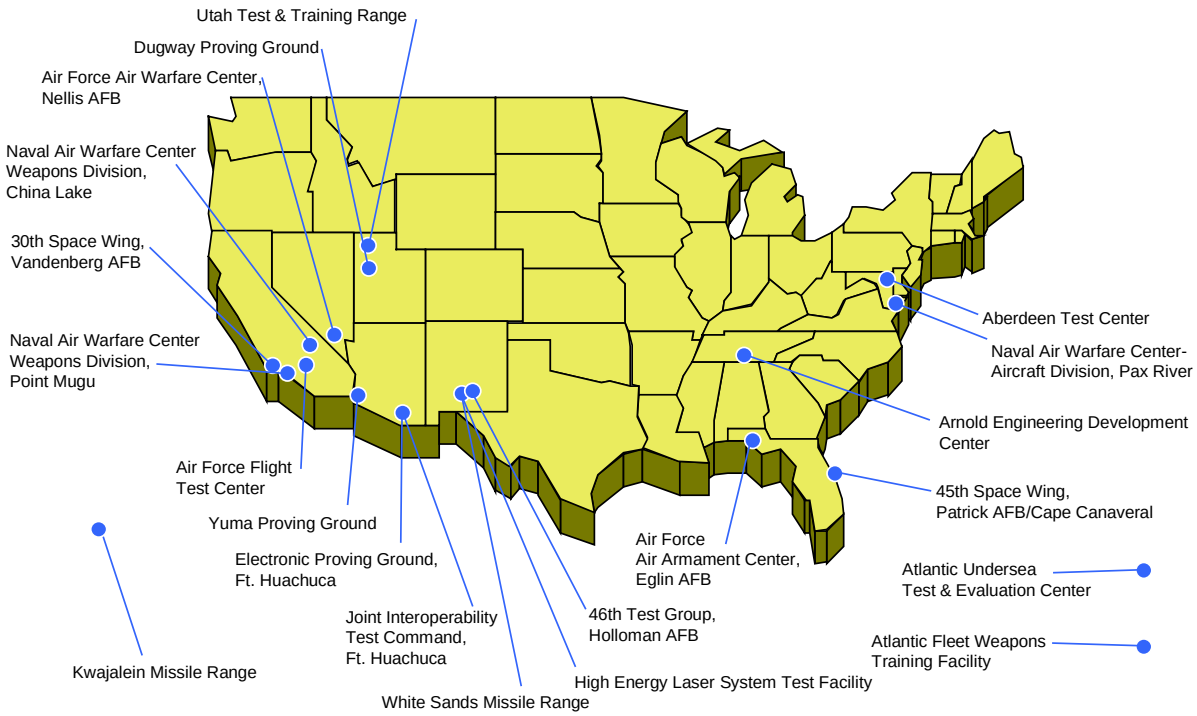
Defense downsizing and the base realignment and closure process have reduced the number of ranges and training areas available to DoD. Other factors, such as advances in weapon system capability and changes in warfighting doctrine, have led to requirements for expanding existing ranges and training areas. The DoD recognizes that land, sea, and airspace are finite resources, and many activities compete for their use. For that reason, it is taking steps to encourage more joint and multifunctional use of ranges and training areas.

The Military Services promote joint-Service and multifunctional use of ranges and training areas. One example involves the operational testing community's use of training ranges to conduct cost-effective operational test and evaluation under realistic conditions by leveraging training events. Additional examples can be seen at installations that host both training and testing functions. For example, the U.S. Army's Fort Rucker in Alabama is home to both the TRADOC Aviation School and the Aviation Technical Test Center. Fort Huachuca in Arizona hosts the TRADOC Military Intelligence School, Forces Command (FORSCOM) Signal and Military Intelligence unit collective training, and the White Sands Missile Range's Electronic Proving Ground, as well as the Joint Interoperability Test Center. Many of the other Army TRADOC schools are assigned inter-Service responsibility for training officers, warrant officers, non-

commissioned officers, and enlisted personnel of other Services (notably the Marine Corps) in technical and branch matters. The Army's two combat training centers in the United States, the National Training Center and the Joint Readiness Training Center, provide joint-Service training with regard to close air support provided by Air Force, Navy and Marine Corps attack units. The Joint Readiness Training Center also provides joint-Service training for airlift, airbase ground defense, associated areas of contingency operations, and joint special operations training. The Pacific Missile Range Facility serves as a fleet training range and is also scheduled to serve as the primary test range for both Navy ballistic missile defense systems: Navy Area Defense and Navy Theater Wide.

The Major Range and Test Facility Base, depicted in Figure 5, provides an excellent example of multi-use ranges. The airspace over three Major Range and Test Facility Base activities in California—Edwards Air Force Base, China Lake Naval Air Station and Point Mugu Naval Air Station—is jointly used by the U.S. Air Force and U.S. Navy to conduct testing and training. The Major Range and Test Facility Base is a national asset that is sized, operated, and maintained primarily for DoD test and evaluation support missions but is also available to all users having a valid requirement for its capabilities, including military trainers. Training activities from small National Guard unit training to joint exercises such as Roving Sands have taken place on Major Range and Test Facility Base ranges. The majority of DoD's test capability is found at Major Range and Test Facility Base activities owned and operated by the Military Services.

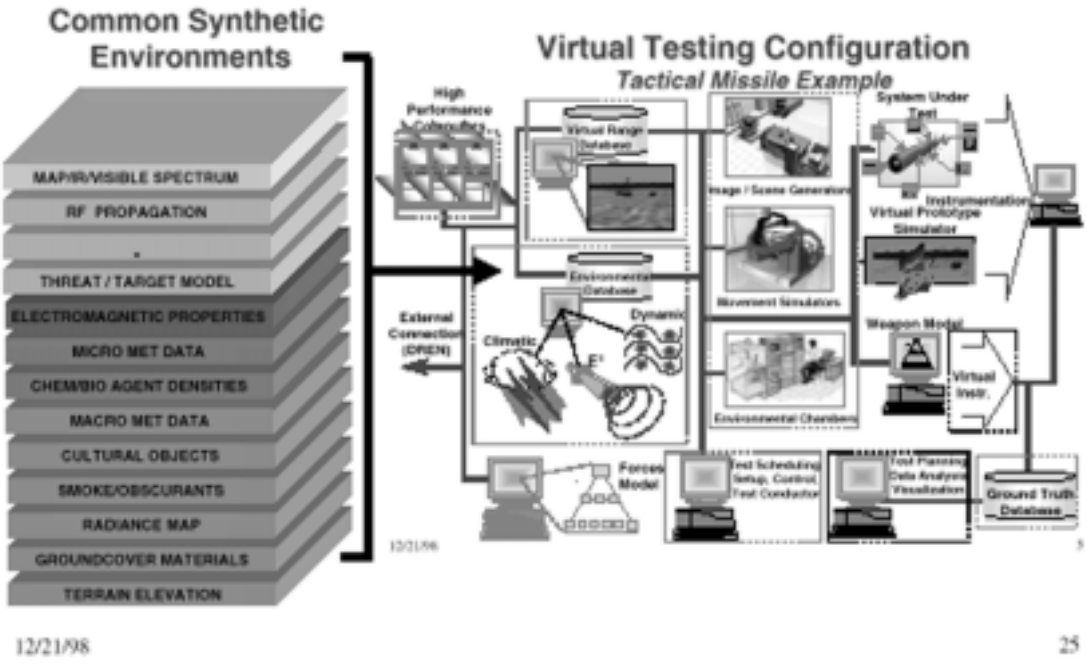
Figure 5. Department of Defense Major Range and Test Facility Base: *The map below shows the location of Major Range and Test Facility Base activities.*



Alternatives to Expanding Land Ranges and Training Areas

For the Military Services, ranges and training areas remain essential assets. Yet, the Military Services are taking advantage of technological advancements in the field of modeling and simulation to enhance training effectiveness and to exercise weapon system capability that cannot be fully employed through conventional means. Figure 6 depicts a typical “virtual testing” configuration. Highly instrumented land ranges serve as the “ground truth” for these synthetic environments. As measurement technology and processing power continue to improve, land ranges will still be used as reference points, for synthetic environment data collection and for baseline comparison testing when virtual prototypes, tested in the virtual world, transition to hardware prototypes that must be tested in the real world.

Figure 6. A typical Virtual Testing configuration and a listing of the types of synthetic environments used in these configurations.



Training simulations are primarily in three domains—live, constructive, and virtual. Live simulations are used by real soldiers operating real weapon systems; however, they enhance the effectiveness of such training. Constructive simulations replicate units, weapon systems, and terrain to support training of battle staffs. This category of simulations has decreased land used when constructive simulations replace what were formerly large-scale exercises. Virtual simulations replicate weapon systems and settings for use during military training. Despite technological advances, simulations will not replace live training on ranges and training areas in the foreseeable future. Simulations cannot replicate the stress, discomfort, and other physical conditions of combat. The Military Services will continue to require soldiers, sailors, and airmen to train in the field under the kinds of conditions they will face in combat.

Much work is being done in the area of models and simulations to reduce the costs, risks, and number of times a range is used. However, if firing is required at a range, running models and simulations will not reduce the requirement to have the land, sea, or air space available when it is needed to enable a combat-ready force.

V. SUMMARY

Ranges and training areas will remain critical assets for the Department of Defense in the 21st century. The ability to train our forces in realistic conditions, test our weapon systems to ensure that they work, and experiment with new joint-warfighting concepts and capabilities are essential to achieving Joint Vision 2010 and national security and military objectives.

Advances in weapon system technology, the emergence of “systems of systems,” and increasing reliance on joint-warfighting doctrine are generating requirements for larger and more capable ranges and training areas in the future. Modern air-to-air warfighting tactics require three times the training area that was required 20 years ago. Ballistic missile defense system capabilities and the requirements to test these capabilities already exceed the Department’s current land ranges and training areas. Requirements are emerging for better urban facilities for urban warfare training. Existing urban warfare ranges do not provide for live-fire, supporting arms usage, close-air support, or training of units above the company level. They also do not come close to replicating the complexities of a city with multiple story buildings, industrial areas, port, railheads, power plants, sewer systems, factories, or shopping malls.

At the same time, increased restrictions are being imposed on range and training area operations in response to local concerns about conflicts between military and civilian use of airspace, noise, and environmental degradation. Many activities compete for the use of finite land, sea, and air space resources. The Department is taking steps to encourage more joint use of existing ranges and training areas and to take advantage of technological development in the area of modeling and simulation to enhance training and support requirements that cannot be fully met through conventional means. However, ranges and training areas large enough to support realistic testing and training are essential to ensure that our forces are ready and able to deter aggression and respond to the full spectrum of threats and crises that may arise.

DoD cannot say with certainty what its requirements for ranges and training areas will be 20, 30, 40, or 50 years in the future. However, DoD's ability to meet future requirements for ranges and training areas will be essential to ensuring ready military forces in the years to come.

APPENDIX A: MAJOR RANGES AND TRAINING AREAS

Table A-1. Major Ranges and Training Areas. *This table lists by location and describes the major ranges and training areas in the United States and its territories. The list represents those ranges and training areas used by DoD as of December 1, 1998.*

Location	Military Service	Range	Major Uses
AK	Air Force	Alaska Air Combat Maneuver Area, Elmendorf Air Force Base	Air-to-air, air-to-ground, electronic combat and live drop systems training instrumented training
AK	Air Force	Yukon Range Complex, Eielson Air Force Base	Multi-Service, many unit, coordinated mock combat operations
AK	Army	Yuma Proving Ground Cold Region Test Center, Fort Greely	Winter, mountain, and northern environment phases of testing of systems, equipment, and materiel
AL	Army	Fort Rucker	TRADOC: Aviation School Aviation Technical Test Center: testing of aircraft, aviation systems, and related support equipment
AL	Army	Redstone Technical Test Center, Redstone Arsenal	Testing of small rockets and guided missiles and support of lighting effects testing
AZ	Air Force	Barry M. Goldwater Range, Luke Air Force Base	Air-to-air, air-to-ground, electronic combat and live-drop training
AZ	Army	Fort Huachuca	TRADOC: Military Intelligence School FORSCOM: Signal and Military Intelligence unit collective training White Sands Missile Range Electronic Proving Ground: test support for command, control and communications systems, electronic combat systems, electro-optic systems, and unmanned aerial vehicles TEXCOM: Intelligence Electronic Warfare Test Directorate
AZ	Army	Yuma Proving Ground	Test support for long-range artillery, rotary-wing aircraft armaments, and armored and wheeled vehicles; tests of various munitions and supply parachute systems
AZ	Defense Agency	Joint Interoperability Test Command, Fort Huachuca	Joint Service/Joint Force command, control and communications test support
AZ	Marine Corps	Yuma Training Range Complex, Marine Corps Air Station Yuma	Tactical air combat range training
CA	Air Force	30th Space Wing, Vandenberg Air Force Base	Space range support, responsible for all government space and missile launches on the West Coast
CA	Air Force	Air Force Flight Test Center, Edwards Air Force Base	Testing of manned and unmanned aerospace vehicles
CA	Army	Camp Roberts	NGB: ARNG and USAR unit collective training and unit schools
CA	Army	Fort Hunter-Liggett	USARC: USAR and ARNG unit collective training

Location	Military Service	Range	Major Uses
CA	Army	National Training Center, Fort Irwin	FORSCOM: CTC and various unit collective training; realistic joint and combined arms training for U.S. and allied warfighters
CA	Marine Corps	Marine Corps Air Ground Combat Center, 29 Palms	Combined arms training
CA	Marine Corps	Pendleton Range Complex, Marine Corps Base Camp Pendleton	Amphibious assault and unit training
CA	Navy	El Centro Range Complex, Naval Air Facility, El Centro	Air-to-ground ordnance delivery training and testing
CA	Navy	Naval Air Warfare Center Weapons Division, China Lake	Air-to-air, air-to-ground, electronic combat, ground-to-air systems, and weapons testing; weapons systems research and development
CA	Navy	Naval Air Warfare Center Weapons Division, Point Mugu	Air-to-air, air-to-ground, electronic combat, ground-to-air systems, and weapons testing
CA	Navy	Southern California Offshore Range, Naval Air Station North Island	Multi-purpose testing and training range for aircraft, aircraft systems, and aircrew
CO	Air Force	Schriever Air Force Base	National test facility for space testing and training
CO	Army	Fort Carson/Pinyon Canyon	FORSCOM: Heavy Brigade collective training USASOC: Special operations unit collective training
FL	Air Force	45th Space Wing, Patrick Air Force Base	Space range support for all East Coast military and commercial launch activity
FL	Air Force	Air Armaments Center, Eglin Air Force Base	Air-to-air, air-to-ground, electronic combat, and ground-to-air systems testing
FL	Air Force	Tyndall Air Combat Maneuvering Area, Tyndall Air Force Base	Airborne air control and aircrew air combat training
FL	Army	Camp Blanding	NGB: ARNG and USAR unit collective training and unit schools
FL	Navy	Key West/Homestead Air Combat Maneuver Area, Naval Air Station Key West	Tactical air combat range
GA	Air Force	Grand Bay Range, Moody Air Force Base	Air-to-ground training
GA	Army	Fort Benning	TRADOC: Infantry School FORSCOM: Heavy Brigade collective training USASOC: Ranger Battalion collective training
GA	Army	Fort Gordon	TRADOC: Signal School
GA	Army	Fort Stewart	FORSCOM: Heavy Division collective training USASOC: Ranger Battalion collective training

Location	Military Service	Range	Major Uses
HI	Navy	Pacific Missile Range Facility	Fleet training range and Ballistic Missile Defense test range
ID	Air Force	Saylor Creek Air Combat and Electronic Range, Mountain Home Air Force Base	Air-to-air, air-to-ground, and electronic combat systems training
ID	Army	Gowan Field	NGB: ARNG and USAR unit collective training and unit schools
IN	Army	Camp Atterbury	NGB: ARNG and USAR unit collective training and unit schools
KS	Army	Fort Riley	FORSCOM: Heavy Brigade collective training
KY	Army	Fort Campbell	FORSCOM: Air Assault Division collective training USASOC: Special Operations units collective training
KY	Army	Fort Knox	TRADOC: Armor School
LA	Air Force	Gulf Port Combat Readiness Training Center	Air-to-air and air-to-ground weapons delivery (inert and live), electronic combat systems training, and practice delivery drop zone
LA	Army	Joint Readiness Training Center, Fort Polk	FORSCOM: CTC and various unit collective training
MD	Army	Aberdeen Test Center	Testing of all weight classes of wheeled and tracked vehicles, robotics, handling equipment, maritime and electronic systems; tank firing, live-fire vulnerability, and underwater shock testing
MD	Navy	Naval Air Warfare Center Aircraft Division, Naval Air Station Patuxent River	Testing of Navy aircraft and aircraft weapons systems
MI	Air Force	Alpena Combat Readiness Training Center, Alpena Air National Guard Base	Air-to-air training ground weapons systems delivery and practice drop zone
MI	Army	Camp Grayling	NGB: ARNG and USAR unit collective training and unit schools
MI	Army	Camp Shelby	NGB: ARNG and USAR unit collective training and unit schools
MN	Army	Camp Ripley	NGB: ARNG and USAR unit collective training and unit schools
MO	Army	Fort Leonard Wood	TRADOC: Engineer, Military Police and Chemical Corps Schools
NC	Air Force	Dare County Air Combat and Electronic Combat Range, Seymore-Johnson Air Force Base	Air-to-air, air-to-ground, electronic combat, and live-drop systems training

Location	Military Service	Range	Major Uses
NC	Army	Fort Bragg	FORSCOM: Airborne Corps and Division collective training USASOC: Special Warfare School training and Special Operations units collective training Test and Experimentation Command Airborne and Special Operation Test Directorate: Testing of equipment, tactics, and procedures for special operations units
NC	Marine Corps	Cherry Point Range Complex, Marine Corps Base Cherry Point	Tactical air combat range and electronic combat systems training
NC	Marine Corps	Lejeune Range Complex, Marine Corps Base Camp Lejeune	Amphibious assault and unit training
NM	Air Force	Holloman Electronic Combat Range, Holloman Air Force Base	Electronic combat systems training
NM	Air Force	Kirtland Air Force	Space research, development, test and evaluation
NM	Air Force	Melrose Air Combat and Electronic Combat Range, Cannon Air Force Base	Air-to-ground, electronic combat, and live-drop systems training
NM	Army	White Sands Missile Range	Test support for missiles, rockets, and sophisticated self-guided munitions
NV	Air Force	Air Warfare Center, Nevada Test and Training Range, Nellis Range Complex, Nellis Air Force Base	Large-force, combined, joint, and coalition air-to-air, air-to-ground, electronic combat and live-drop systems training; full-spectrum air combat training complete air combat training
NV	Navy	Fallon Range Training Complex, Naval Air Station Fallon	Tactical air combat range and electronic combat systems training
NY	Army	Fort Drum	FORSCOM: Light Division collective training
OK	Army	Camp Gruber	NGB: ARNG and USAR unit collective training and unit schools
OK	Army	Fort Sill	TRADOC: Field Artillery School FORSCOM: Heavy Field Artillery unit collective training Test and Experimentation Command—Fire Support Test Directorate: Operational testing of field artillery systems
PR	Navy	Atlantic Fleet Weapons Training Facility, Naval Air Station Roosevelt Roads	Fleet training range

Location	Military Service	Range	Major Uses
SC	Air Force	Poinsett Air Combat and Electronic Range, Shaw Air Force Base	Electronic combat systems training Air-to-air, air-to-ground, and electronic combat training
SC	Army	Fort Jackson	TRADOC: Basic Combat Training Center and CSS branch schools
SC	Marine Corps	Beaufort Range Complex, Marine Corps Air Station Beaufort	Tactical air combat range and electronic combat systems training
TX	Army	Fort Bliss	TRADOC: Air Defense Artillery School FORSCOM: Air Defense Brigade collective training Test and Experimentation Command—Air Defense Artillery Test Directorate: support for Army air defense artillery school and operational test support for hardware and software systems
TX	Army	Fort Hood	FORSCOM: Heavy Corps and Division collective training Test and Experimentation Command—Command, Control and Communications Test Directorate: Testing of Army combat command, control and communications systems
UT	Air Force	Utah Test and Training Range, Hill Air Force Base	Air-to-air, air-to-ground, electronic combat, and ground-to-air systems training and testing
UT	Army	Dugway Proving Ground	Environmental technology testing and testing of biological defense, chemical defense, incendiary, smoke and obscurant systems
VA	Army	Fort AP Hill	Military District of Washington: Light Infantry unit collective training USAR and ARNG: RC unit collective training
VA	Army	Fort Eustis/Story	TRADOC: Transportation School FORSCOM: Transportation Group collective training
VA	Army	Fort Lee	TRADOC: Quartermaster School
VA	Navy	Oceana Range Complex, Naval Air Station Oceana	Tactical air combat range and electronic combat systems training
WA	Army	Fort Lewis / Yakima	FORSCOM: Light and Heavy Brigade collective training USASOC: Special Operations unit collective training
WI	Air Force	Hardwood Range, Volk Field Combat Readiness Training Center	Air-to-ground , instrumented weapons delivery training
WI	Army	Fort McCoy	USARC: USAR and ARNG unit collective training and unit schools

APPENDIX B: SELECTED BIBLIOGRAPHY

This appendix presents a selected bibliography of references where the reader may obtain additional information.

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ABBREVIATIONS

AAAV	Amphibious assault vehicle
AC	Active Component
ACC	U.S. Air Force Air Combat Command
AEF	Air Expeditionary Force
ARNG	Army National Guard
ATACM	Army Tactical Missile System
BAT	Brilliant Anti-Armor Tactical
BMDO	Ballistic Missile Defense Organization
C4I	Command, Control, Communication, Computers and Intelligence
CINC	Commander In Chief
CTC	Combat Training Center
DoD	Department of Defense
EAF	Expeditionary Air Force
EC	Electronic Combat
FORSCOM	U.S. Army Forces Command
ITAM	Integrated Training Area Management
KMR	Kwajalein Missile Range
LGB	Laser Guided Bomb
MEF	Marine Expeditionary Force
MLRS	Multiple Launch Rocket System
NEF	Naval Expeditionary Force
NMD	Nation Missile Defense
RC	Reserve Component
RDT&E	Research, Development, Test and Evaluation

RF	Radio Frequency
SLAM	Standoff Land Attack Missile
SLAM-ER	Standoff Land Attack Missile – Expanded Response
TMD	Theater Missile Defense
TRADOC	U.S. Army Training and Doctrine Command
U.S.	United States
USAR	U.S. Army Reserve
WSMR	White Sands Missile Range